

THORNBURY (F. J.)

The Demands for Sterilization.

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THE DEMANDS FOR STERILIZATION.*

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WATER from the interior of the earth, such as that obtained by artesian wells, is entirely free from germs, but water which stands or flows over the bacteria-enriched ground contaminated through decomposed organic material contains myriads of living organisms.

The numbers of bacteria present fluctuate between the few to the cubic centimetre contained in ordinary well and spring water to the millions to the cubic centimetre found in river and canal water.

For a long time it has been the popular belief that water might be the source of various forms of infection, and with our present understanding of intestinal mycosis we know that not only cholera and typhoid but many other serious alimentary diseases are directly traceable to this source.

It is true that the water bacilli are for the most part those which do not belong to the germs of wound infection, although some most virulent varieties of bacteria have repeatedly been found in water.

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It is only necessary to recall the fact that the most disastrous of the animal septicæmias—namely, the *rabbit septicæmia bacillus* discovered by Koch and Gaffgy—was first found in a tributary of the Spree River, flowing through Berlin.

Rinantro Mori has isolated from canal water three pathogenic bacteria. According to Lortet and Despeignes, the Rhone River water of Lyons contains scarcely anything excepting organisms which are pathogenic. The filter residue and precipitate injected subcutaneously into guinea-pigs caused a rapidly fatal septicæmia and pyæmia. Repeatedly the presence of pyogenic staphylococci has been detected in the examination of river and well water. With a knowledge of the virulent characteristics of these bacteria such water would be drunk with much hesitation.

The hydrant water of Freiburg, Germany, frequently contains the green pus *Bacillus pyogenes*. Most bacteria can maintain their vitality for weeks and even months in water. The water serves as a culture medium for many; they thrive and multiply in it by spontaneous proliferation.

The bacteriological tests of Cramer showed that Zurich hydrant water increased twenty-seven thousand times in its septic contents after standing for twenty-four hours. And Leon ascertained that the supply water of Munich, which contained only five bacteria to the cubic centimetre, after standing for five days showed five hundred thousand germs to the cubic centimetre.

Certain of the saprophytic bacteria grow best in water, and they here come to a luxuriant development. According to Wolffhugel and Ridet, sterilized river water mixed with distilled water is a favorable nutrient medium for anthrax, and Gioxa has shown that this is true of other pathogenic bacteria which are of interest to us aside from anthrax.

Reference to the chart prepared by Houlwa giving results of his investigations into the water supply of the city of Breslau is quite sufficient to convince us of the multiplicity of forms of animal life found in water.

It is conclusively demonstrated that water may be a source of danger from hygienic and bacteriological stand-points. It seems positively unjustifiable to permit its application to wounds without first subjecting it to a thorough sterilization.

While we can hardly as yet sterilize the entire water supply of a city, demonstrated facts in hygiene demand that we sterilize the water used about operations—*i. e.*, in cleansing the hands of the operator, the field of operation, the instruments, and the utensils.

Precipitation by the addition of some finely powdered and insoluble substance, filtration by use of sand or the Pasteur-Chamberlain filter, then destroying the germs by the addition of antiseptics, and finally sterilization by heat, are the various means of rendering water fit for surgical use.

When water is allowed to stand for a time, of course the bacteria settle to the bottom in accordance with the laws of gravity. The precipitation may be further facilitated by the addition of sand, calcium carbonate, or certain other finely granular substances. Regarding filtration, by reason of the fact that water in the interior of the earth is free from bacteria, it has been thought that we might imitate Nature in so far as to be able to extract from hydrant water its germs and impurities by a process of filtration; but such a degree of perfection we have, unfortunately, as yet not been able to attain.

The Pasteur-Chamberlain filter, while valuable and capable of markedly improving the quality of the water, does not render it absolutely free from bacteria. Perhaps for the first four or five days there are no germs present and it

functionates fairly well ; but after this time the quantity of water which the filter will allow to pass gradually diminishes, the pores become partially occluded, and finally germs filter through.

The antisepticizing of water by the addition of chemical substances merits just a few explanatory statements for the correction of certain erroneous ideas which I believe to exist.

Bichloride of mercury does not insure immediate death of everything in the way of germs, as ordinarily supposed. *Staphylococcus pyogenes* and *Bacillus pyocyaneus* live for a quarter of an hour in a one-per-cent. solution. Anthrax spores resist a one-per-cent. solution for twenty-four hours. Boric acid, ammonia, and absolute alcohol have little influence upon them. They survive a five-per-cent. carbolic solution for days. Tetanus, tubercle, and spores of other pathogenic bacilli present similar degrees of resistance.

Clear spring water, in which the individual bacilli are suspended isolated, may be disinfected, but the highly contaminated water of rivers and ponds, containing gross visible masses of impurity rich in bacteria, does not admit of being rendered sterile by the addition of antiseptics. Heat is the only absolute agent—simple in its application, most rational and reliable. The spores of anthrax, the most resistant pathogenic spores known to us, are completely destroyed by boiling in water for three minutes. Five minutes of boiling them must remove every reasonable possibility of any germs remaining alive.

Miquel found that of one thousand bacteria in water, 95.5 per cent. were destroyed by short boiling. Water of the river Rhône, which contained thirty-three thousand bacteria to the litre as revealed by the investigations of Lortet, lost through boiling all but nine hundred and forty-one bacteria, or over ninety-seven per cent. Bacteria which resist

boiling water are only such as possibly the hay bacillus—*i. e.*, non-pathogenic, and consequently unimportant.

The absolute certainty of heat sterilization and its readiness of application strongly makes it desirable that every surgeon shall provide a sufficient quantity of sterilized water for use in his operating room or clinic. And as there are bacteria that thrive and multiply in water, it is necessary that after boiling it be closed hermetically, or, preferably, boiled fresh each time it is needed.

Sterilizing in bottles is only adapted to limited use; for hospitals and clinics and general operative purposes a special apparatus is necessary.

The relation of cause to effect existing between the occasional occurrence of abscesses in association with hypodermic injections has been recognized since an early period in the use of the hypodermic syringe.

We have the one instance in which four consecutive tabes patients were inoculated with erysipelas and three of them died. Two typhoid patients in a state of collapse developed rapidly fatal purulent œdema following injection of tincture of musk. Two cases of fatal phlegmon resulted from the subcutaneous administration of quinine (Leyden's clinic, Charité, Berlin).

The inoculation of anthrax in the injection of a solution of arsenic has been observed in the Breslau clinic of dermatology. Two cases of tuberculosis are lately recorded, one by König and the other by Eiselsberg.

There has been in general too little attention given to the liability of the presence of organisms in injected fluids. Schimmelbusch and Hohl have shown that the hypodermic solutions obtained from various apothecaries' shops in Berlin contain vast numbers of live bacteria. The germs present in a one-per-cent. pilocarpine hydrochloride solution were innumerable. In an ordinary solution of ergotine there were

ten thousand bacteria to the cubic centimetre. Solutions of atropine, morphine, and cocaine hydrochloride also were rich in organisms.

It is quite important that we should recognize that the pus-formers—the Fehleisen erysipelas streptococcus and other pathogenic organisms—multiply in the fluids which we are injecting into the body.

Ferrari has recently shown that in one-per-cent. solutions of morphine and atropine the organisms not only *live* for weeks, but indeed *increase* with marvelous rapidity and form pure cultures in the fluid.

In glycerin the *Staphylococcus pyogenes aureus* remains alive and active for six days, then gradually dies. In two-per-cent. morphine solutions it retains its vitality for twenty-four hours; in ten-per-cent. cocaine solutions for two hours. Only in the stronger solutions—such as those of ether, musk, quinine bisulphate, fifty-per-cent. antipyrine, and twenty-per-cent. caffeine benzoate—does it die at once. In 0·15 to 30·0 per cent. strychnine sulphate bacteria live for eight days. In one-per-cent. hydrochloride of cocaine, after nine days, thousands were still alive.

That the subject of the bacterial contamination of hypodermic solutions and the consequent danger of subcutaneous medication merits some attention, therefore, must be conceded.

Not only should we sterilize prepared hypodermic solutions and use sterilized water in dissolving morphine and other tablets, but the syringe and needle also should be sterilized.

Five minutes' submersion in boiling water suffices to render the instrument aseptic. The fluid may be heated in a test-tube over the gas or lamp flame.

The mechanical cleansing, which should constitute the preparatory part of every sterilizing procedure, for re-

moval of the grosser contamination—such as dried blood, pus, and masses of fat—does not, of course, insure an absolute asepsis.

The instruments will often still be found to contain many varied forms of micro-organisms strewn promiscuously over their surface.

For the removal of this final but important source of error the impracticability of the successful use of carbolic, boric, or salicylic acid solutions, or even bichloride of mercury, by pouring one of the latter over the instruments for a few minutes, is proved by the foregoing references and demonstrated facts.

The instruments must be sterilized, and the choice of method lies between hot air, steam, and boiling solutions. Only the latter of these shall I consider. Spores of many bacilli resist hot air at 140° for two hours and steam for forty minutes to an hour, while *boiling in soda insures absolute death of even anthrax spores in from three to five minutes.*

Catheters, sounds, and bougies also merit some attention, since it has been proved that most cases of severe cystitis are due to the introduction of germs into the bladder by unclean instruments. The urine in the healthy bladder is normally free from bacteria, and decomposition does not occur without external cause. There are few practitioners who have not observed the development of cystitis after a single urethral exploration or repeated catheterism. Rosving has found frequently staphylococci and streptococci identical with known pathogenic species in ætiological association with vesical inflammations. In thirteen cases out of twenty of purulent cystitis, the younger Schnitzler was able to trace the cause to a certain bacterium, which he names *Urobacillus pyogenes septicus*. By the introduction of his *Urobacillus pyogenes septicus* into the healthy bladder of animals, Schnitzler was able to produce the most virulent cystitis.

It is not sufficient for disinfection to simply dip the sounds, catheters, and bougies into antiseptic solutions or lubricating oils. Many of these combinations themselves contain live bacteria.

Koch long since demonstrated that antiseptic oils were, to say the least, ineffectual. In the first place, the chemical substance does not dissolve thoroughly in the oil. Secondly, the oil does not permeate the septic material. Silk threads, impregnated with pus and then dipped into oil, may be submerged in a 1-to-200 corrosive-sublimate solution for days and weeks without injuring the bacteria.

Analogous instances are found in attempts at destroying the bacteria imbedded in the sebaceous secretions of the skin and in the fat of the skin and of lubricated catheters.

Thus we see the absurdity of simply washing the hands superficially or rinsing them in bichloride, and also the uncertainty of attempts at sterilizing catheters by simply dipping them in carbolized or other "antiseptic" oil. The same also applies to the preparation of catgut by the popular method of "carbolizing" it. The oil itself is not reliably sterilized by the addition of chemical substances, as shown in the foregoing statements. The same is true of water-antiseptic solutions.

Sounds, of course, admit of being sterilized in heat, the same as other metal instruments; so also do Albarran's caoutchouc catheters. The soft-gum and lac catheters do not tolerate boiling, however; consequently they may be continuously submerged in strong carbolic-acid or corrosive-sublimate solutions—our next best substitutes—although each time before being introduced they should be rubbed with sterile gauze, or washed in sterilized water, to remove the antiseptic, which is very irritating to the urethral canal. The rubbing in itself is an efficient mechanical aseptic, as shown by Schimmelbusch, who infected red lac

catheters with pure cultures of various bacteria, and found that, after a minute of active rubbing with moist, then dry, sterile gauze, the instruments were completely sterilized. We have the two associated factors of friction and heat as explanatory.

Regarding the cleansing of the hands, above incidentally referred to, they, of course not being sterilizable, should be treated with soap and brush, ether, alcohol, or corrosive sublimate, using sterilized water. But the brushes themselves must be kept clean, otherwise they may be a source of danger. Used in removing blood, pus, surface epithelium, and all forms of contamination, they become more or less contaminated themselves; being moist, they retain most of the albuminous matter, and form a most excellent nidus for germs.

Schimmelbusch and Spielhagen, in repeated examinations of the nail-brushes in clinics, dissecting-rooms, and laboratories, found in them inestimable myriads of bacteria.

That the brushes, therefore, merit some attention must be conceded. In the von Bergmann clinic they are dealt with in the following manner: Before being used they are first sterilized in steam for thirty minutes; second, they are kept continually submerged in a half-per-cent. corrosive sublimate; third, after a special contamination they are placed in very hot and finally in *boiling* water.

In every commode there should be a receptacle in which the brush can be kept submerged in the bichloride. The latter will maintain asepsis after the brush has been sterilized by boiling.

Sponges are proverbially a source of danger, and twenty per cent. of those prepared for use in Billroth's clinic were found by Frisch to contain bacteria. Absorbing so freely into their intricate capillary network blood, pus, and all fluids, contaminated or not, they are, *a priori*, apt to retain

and convey infection and permit only with difficulty of being sterilized. Anthrax spores are found in sponges after being fourteen days submerged in carbolic acid. The ordinary organisms live for eight days.

But it is difficult to dispense with sponges entirely, especially in operations about the mouth, resections of the jaw, etc., and laparotomies. And they may be sterilized if heat is employed.

The method practiced by Schimmelbusch consists in first washing them thoroughly in hot water, removing carefully all foreign matter. After several rinsings they are boiled for thirty minutes in a one-per-cent. soda solution, then preserved in strong corrosive-sublimate solution. This method may be regarded as absolute. Sponges impregnated with pus and anthrax spores did not react to culture efforts after ten minutes in the boiling soda.

Since it has been shown that raw catgut is rich in bacteria, and Volkmann has had two cases of anthrax develop in a wound sutured with ligature from the sheep, in which animal anthrax is common; further, by reason of Koch's having demonstrated that antiseptic oils are ineffectual, as above shown—we are required to put catgut and other suture materials also through a course of sterilization. Steam for the silk is best, and Schimmelbusch's spool boxes, in which the ends of the threads protrude from the side, may be used. For preparing the catgut, von Bergmann's method is best: First, the bottle is sterilized for three quarters of an hour in steam; second, there is a process of deoleation by placing the catgut for twenty-four hours in ether; third, there is a submersion in alcohol and corrosive sublimate of the following proportions: bichloride, 10·0; absolute alcohol, 800·0; aq. destillata, 280·0.

The subject of drainage-tubes merits a passing notice. The necessity of their being sterile requires no argument.

The glass and rubber tubes may be boiled in soda or sterilized in steam. Five minutes of the former, fifteen or twenty of the latter, is sufficient to render them reliably aseptic.

All of the articles and materials used in the disinfection of the surfaces, cutaneous and mucous, must of course themselves be aseptic. The alcohol, ether, and turpentine oil are kept free from bacteria only by careful handling.

Eiselsberg showed in 1878 that soap was richly impregnated with micro-organisms, and only that which had been boiled in the process of its manufacture should be used.

Last, but none the less important, we have the dressings to speak of.

Sterility as a prerequisite is absolute, and this applies to everything that is to come in contact with pure, fresh wounds. Both Schlange and Löffler have found gauze bandages, etc.—factory supplies—to contain many germs. The necessity of sterilizing the dressings then follows as a natural consequence. Saturating them with antiseptics is ineffectual. We now know that the action of most chemical solutions must continue for a long time, often for days, before certain resistant spores are destroyed, and the effect may at best be entirely nil when there are present the more or less impermeable layers of fat and albuminous substances in which the bacteria are often imbedded.

Even though it be conceded that the gauze and other materials have been sterilized by the transitory and more or less imperfect saturation with some of the popular antiseptics—carbolic acid, boric acid, or corrosive-sublimate solutions—as the work is done in the manufactory, they would be afforded innumerable opportunities for reinfection in the subsequent handling by three or four different persons, in cutting, folding, and packing the dressings for shipment, and the reverse of this process after they had reached the surgeon. Further, it is not with bouillon or water that we

have to deal in a wound, but rather with albuminous culture material, which decidedly limits the action of chemicals. Combinations form, reducing the effectual working of the carbolic acid, corrosive sublimate, and other agents, and more or less evaporation occurs. In sublimated gauze, after a time only an insignificant trace of the original antiseptic is to be found. In solution also the bichloride is changed by the alkaline earths of ordinary water, although the combinations may to some extent be obviated by the addition of an equal quantity of chloride of sodium.

Thus we see the unreliability of antiseptic asepsis in dressings, and the inconsistency of relying on factory-prepared supplies.

Asepsis permanent and reliable, implying the avoidance of uncertainties and these various subsequent liabilities to contamination, may be accomplished in a simple manner by sterilizing the dressings by heat applied especially in the form of steam. Not only by reason of convenience and greater reliability in the absolute destruction of all pathogenic organisms does the steam sterilization recommend itself over the impregnation with antiseptic agents, but further in that at any time, on short notice and in but a few minutes, the work can be executed. A secondary handling of the dressings is also obviated; they are preserved in closed boxes, in which they remain until applied directly to the wound—*i. e.*, they are made ready for use before being put into the sterilizer. The bandages are rolled, the cotton is cut into strips, and the gauze is divided into such lengths as may be desired. The whole is then put into the small box receptacles and sterilized with lid and bottom orifices open; afterward they are dried and tightly closed. The dressings are then protected from every source of contact and contamination and there is no further handling of them until they are applied directly to the wound.

This principle of closed boxes for dressings is especially important and is infinitely more reliable than the storing of dressing in drawers, closets, or other less cleanly places (Schimmelbusch).

With reference to the heat sterilization of the metal instruments, I wish to lay special stress upon the use of the boiling soda solution. First introduced into practice by Davidsohn in a contribution from the Koch laboratory about two years and a half ago, it has gradually gained ground until it has attained the present distinction of being our most valuable and powerful disinfecting agent. Other alkalis had been added to the boiling water to supplement its sterilizing action, such as chalk, chloride of sodium, and caustic soda, but none of these have been found to possess the saponifying and permeating value of the washing soda. Its use in household practice for dissolving away dirt and for cleansing purposes generally is the most forcible argument in its behalf. Simple boiling water is in itself decidedly superior to either hot air or steam, as it destroys in five minutes the most resistant micro-organisms. But the instruments rust if boiled simply in water, especially if the water is cold when they are put into it, while by the use of soda, with the additional precautions of rubbing and drying the instruments, the rusting may be avoided. The sterilizing action of the boiling water is further intensified by the dissolving action of the soda. "We may say the boiling soda solution forms the most powerful disinfecting agent known to us, the use of which is applicable in practice. Silk and heavy wool threads impregnated with pus and pure cultures of the *Staphylococcus pyogenes* and *Bacillus pyocyaneus* are invariably destroyed in two to three seconds, and anthrax spores in two minutes, by submersion in the boiling soda solution" (Schimmelbusch).

The imperative necessity of sterilizing practically every

article of the surgeon's paraphernalia being now understood, the demand for a single apparatus in which all the work can be accomplished naturally suggests itself. This indication I hope to have fully met in the combination sterilizer which I have the pleasure to present with illustration in this issue of the *Journal* (see New Inventions). Apparatuses have been devised for sterilizing water, there is a useful apparatus for instruments, and others have been devised for sterilizing dressings, but a combination apparatus in which all these three purposes can be accomplished in one has not as yet, to my knowledge, been invented. The necessity for such an apparatus seems to be very positive, as most practitioners can not well have three sterilizers—one for water, another for instruments, and another for dressings. If all these requirements could be combined in one apparatus, however, made of proper proportions and inexpensive, it would naturally come within reach of a greater number of those requiring a sterilizer. The number who do require a sterilizer corresponds with the number who make any pretensions to doing surgical work.

My special aim in the designing and execution of this apparatus* has been to bring it within reach of the general practitioner; its construction and use are simple and it may be arranged for working in almost any office. Where gas is not used the alcohol lamp may be employed for heating, but the supply bottle should be placed to one side and the wicking conducted through a tube to supply the flame underneath the boiler; thus the danger of an explosion by the boiling point of the alcohol becoming reached is obviated.

* Obtainable from Jeffrey & Gotshall, Buffalo, N. Y.



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